Chapter 11: Reproduction — How Life Continues

Redeveloped Edition | Class 9 Science | IESC Series

Original NCERT content reimagined with everyday life examples, creative AI-enhanced exercises, and interdisciplinary insights.

Opening Wonder

A potato sits forgotten at the bottom of the sabzi basket for two weeks. When you finally pull it out, it has grown pale, curling shoots from little dents on its skin — the "eyes." You didn't plant a seed. Nobody watered it. Yet, given warmth and a little darkness, that single potato is quietly getting ready to become several new potato plants.

A few kilometres away, after the first heavy monsoon shower, mushrooms push up through a garden bed overnight — pale umbrellas that were nowhere to be seen the previous evening. And in an orchard in Ratnagiri or Malihabad, a farmer takes a thin branch from a prized Alphonso or Dasheri mango tree and carefully binds it onto the trunk of an ordinary seedling. A year later, that ordinary tree is producing exactly the same sweet, fibreless mangoes as the original — not a slightly different fruit, but a precise copy.

These are three completely different routes to the same destination: new life. The potato multiplies without needing another potato plant at all. The mushroom's spores travelled invisibly through the air until they found moisture. The grafted mango tree was deliberately built — one plant's living tissue fused onto another's — to guarantee that the next generation of fruit would be identical to a parent that took decades to perfect.

Contrast this with a mango seed itself: plant it, and the tree that grows will very likely bear fruit that tastes noticeably different from its parent — sourer, stringier, or simply not as good. Why does one route to a "new mango tree" preserve every detail of the original, while the other scrambles the recipe?

This chapter is about exactly that question — how living things, from single yeast cells to flowering mustard fields to human beings, continue their kind. You will meet two fundamentally different strategies: **asexual reproduction**, where one parent produces genetically identical copies of itself, and **sexual reproduction**, where two parents combine their genetic material to produce offspring that are related to, but never identical to, either parent. Both strategies are visible all around you — in your kitchen, your terrace garden, the monsoon puddles outside your school, and inside your own body as it changes through adolescence.

11.1 Asexual Reproduction

Asexual reproduction involves only a single parent, and it produces offspring that are genetically identical to that parent. It is common in unicellular organisms such as bacteria, amoeba and yeast, and in simple multicellular organisms such as hydra and sponge. It is also widespread among plants.

Many plants sprout new shoots and roots directly from their existing parts, without ever forming a seed. Potato and ginger are fleshy underground stems that sprout new plants from their "eyes" (buds). A piece of money plant stem or a sugarcane cutting placed in water or soil grows roots and becomes a complete new plant. A Bryophyllum leaf sprouts tiny plantlets along its notched margins, and each one can grow into an independent plant. All of these are examples of **vegetative propagation** — new plants arising from the vegetative (growing, non-reproductive) parts of a parent plant. Because only one parent is involved, every plant produced this way is a genetic copy of the original.

> **Everyday Connection: The Sabzi Basket and the Balcony Garden**
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> You have almost certainly seen vegetative propagation without naming it. A potato left too long in the kitchen sprouts eyes. Ginger left in a masala dabba sprouts a green shoot. A broken piece of money plant vine, dropped into a glass bottle of water on a windowsill, grows a tangle of white roots within a fortnight and can then be potted as a brand-new plant. Coriander and mint stems from the vegetable market, kept in a katori of water, will often root the same way.
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> None of this required a flower, a seed, or a second parent plant. It happened because the stem and leaf tissue of these plants retains the ability to regenerate missing parts — roots, shoots, an entire new individual — from a small fragment of itself.

11.1.1 Vegetative Propagation in Agriculture: Cutting, Grafting, Layering and Tissue Culture

Because asexual reproduction produces genetically identical individuals, scientists and horticulturists have adapted this natural process into deliberate techniques for cultivating plants at scale: **cutting**, **grafting**, **layering**, and **tissue culture**. These methods let farmers reproduce a single high-quality plant thousands of times over, instead of leaving the outcome to the genetic lottery of seeds.

Cutting: A healthy branch is cut from a parent plant, generally at the end of its growing season. Leaves are removed from the lower half of the cutting, which is then inserted at an angle of about 45–60° into soil mixed with compost and watered regularly until it roots. Roses, hibiscus, sugarcane and money plant are commonly propagated this way.

Grafting: A healthy rooted plant (called the stock — for instance, a hardy wild rose or an ordinary mango seedling) has a wound or slit cut into one of its twigs. A stem piece from a different, more desirable plant (the scion — for instance, a specific rose colour, or a branch from a prized Alphonso mango tree) is inserted into that slit. The wound is bound with cloth or grafting film to keep out pests and moisture until it heals and fuses. The resulting plant grows the root system of the

sturdy stock but produces the fruit or flowers of the scion — genetically identical to the parent the scion was cut from.

Layering: A flexible, low-growing twig — of a lemon tree, for example — is bent down and its middle portion is buried under the soil while it is still attached to the parent plant. After 10–15 days, roots develop from the buried section. Once rooted, the twig is cut away from the parent and grows independently.

Tissue culture: Farmers are supplied with mass-produced, healthy plantlets grown in a laboratory from the shoot tip (apical meristem) of a parent plant. Because these plantlets are grown from carefully selected, disease-free tissue under sterile conditions, this technique eliminates virus-infected stock and ensures uniformly high yields — and it, too, is a form of asexual reproduction, since the new plants are clones of the parent tissue.

Everyday Connection: How Your Alphonso Mango Got Its Exact Taste

If you have ever wondered why every Alphonso mango tastes recognisably like an Alphonso, no matter which orchard in Ratnagiri or Devgad it came from, the answer is grafting. Mango trees grown directly from seed show huge variation in taste, size and fibre content — a seedling is the product of sexual reproduction and inherits a new, unpredictable mix of characteristics. So orchardists graft a scion from a proven Alphonso, Dasheri or Langra tree onto hardy rootstock. Every grafted tree is, genetically, the same plant repeated over and over across thousands of hectares.

Krishi Vigyan Kendras (KVKs), run under the Indian Council of Agricultural Research (ICAR), train farmers across India in exactly these techniques — cutting, grafting and layering — as vocational skills, alongside marketing and access to government schemes, helping them grow higher-yield fruit and improve their income.

Tissue-culture banana farming shows the same idea at industrial scale. Instead of using suckers dug up from an existing banana clump (which can carry disease), farms in states like Maharashtra and Gujarat now buy lab-grown plantlets propagated from the apical meristem of elite, disease-free mother plants. A banana orchard raised this way is far more uniform in yield and far less likely to collapse from a single infected sucker spreading disease through the whole field.

Activity — Redeveloped: Reading a Nursery Like a Scientist

Original book version: Interact with gardeners or farmers working in a school garden or field; observe the techniques of cutting, grafting and layering; record your observations in a notebook.

Everyday Version:

Visit a neighbourhood plant nursery, a terrace/balcony garden, or the gardener who tends your school's grounds. Instead of just watching, run this structured investigation:

- Ask which plants are grown from seed and which are grown from cuttings or grafts — and why the nursery chooses one method over the other for each.
- Find a grafted plant (roses and mango saplings are common in Indian

nurseries). Look for the graft union — a slightly swollen, scarred ring on the stem where scion meets stock.

- Count the nodes and internodes on a fresh cutting the gardener is preparing. Note its length and the angle at which it is pushed into the soil.
- Ask: "If I plant this cutting, will the flowers/fruit look exactly like the parent plant?" Record the gardener's answer and compare it with what you now know about asexual reproduction.

Why this matters: A gardener who has never opened a biology textbook is applying genetics correctly every single day. Fieldwork like this connects a formal concept (asexual reproduction produces clones) to a skilled trade practised across India.

Budding: Yeast and Hydra

In yeast (a unicellular fungus), small, round outgrowths called **buds** appear on the surface of the parent cell. Each bud enlarges and eventually separates to live as an independent yeast cell. In **hydra**, a simple multicellular animal found in freshwater ponds, repeated cell division at a specific site on the parent's body produces a small outgrowth, which enlarges and detaches to live independently — often with several buds visible on one hydra at the same time. This process is called **budding**.

Everyday Connection: The Yeast Sachet in Your Kitchen

Home baking has become a common hobby in Indian kitchens — pizza dough, buns, and bread all rely on instant yeast sachets from the grocery store. When you mix that yeast with warm sugared water, it doesn't just sit there: within minutes the mixture froths and a balloon stretched over the bottle's mouth begins to inflate. That gas is carbon dioxide, a by-product of yeast cells respiring and budding rapidly as they feed on the sugar.

Under a microscope, the same yeast would show small round buds pinching off the sides of parent cells — visual proof that the population is reproducing asexually, cell by cell, which is exactly why a small sachet of yeast can leaven an entire batch of dough within an hour.

Activity — Redeveloped: Watching Yeast Multiply

Original book version: Prepare 20 mL of sugar solution in a test tube, add a pinch of yeast, keep it warm, then examine a drop under a compound microscope for budding.

Everyday Version — The Balloon Fermentation Test:

- Dissolve 2 teaspoons of sugar in 100 mL of lukewarm water in an empty plastic bottle.
- Add one teaspoon of instant/dry yeast (the same kind used for bread or pizza dough) and swirl gently.
- Stretch a small balloon over the bottle's mouth and place the bottle somewhere warm for 30–60 minutes.

- Observe the balloon slowly inflating — evidence of the carbon dioxide gas released as yeast cells respire and reproduce rapidly.
- If a microscope is available at school, take a drop of the frothy liquid, mount it on a slide, and look for small round buds projecting from parent cells — the direct visual evidence of budding.

Think about it: Why does the balloon stay flat if you use cold water instead of lukewarm water? (Hint: yeast reproduction, like most biological processes, is temperature-sensitive.)

Spore Formation: Fungi

Leave cooked food on the kitchen counter in warm, humid weather and it soon smells and grows fuzzy patches. Damp walls during the monsoon often develop black patches. These are fungi — organisms such as *Rhizopus* and *Aspergillus* — reproducing by **spore formation**. Spores are produced in a sac-like structure at the tip of thread-like fungal filaments called hyphae, or on a swollen vesicle along the hyphae. A single mould colony can release millions of spores. Spores are extremely lightweight, usually single-celled, and float easily through air currents. When a spore lands somewhere with enough moisture and nutrients, it germinates quickly into a new fungal individual.

For centuries, people believed that living things like mould could arise spontaneously from non-living matter such as stale bread. Experiments by the French scientist **Louis Pasteur** proved this wrong: new life always arises from pre-existing life. Pasteur's work established the germ theory of disease, strengthened the cell theory (all cells arise from pre-existing cells), and led directly to practices such as sterilising food and surgical instruments.

Meet a Scientist: Louis Pasteur — The Man Who Ended "Spontaneous Generation"

Louis Pasteur (1822–1895) was a French chemist and microbiologist. In the mid-1800s, most scientists still believed that maggots, mould and microbes could spontaneously appear from decaying matter with no living parent at all. Pasteur designed a now-famous experiment using **swan-necked flasks**: broth was boiled inside a flask whose long, curved neck let air in but trapped dust and airborne microbes in its bend, so they never reached the broth. The broth stayed sterile indefinitely — proving that microbial growth requires microbes to actually arrive, not spontaneous creation from the broth itself.

This single experiment reshaped biology and medicine. It underpins **pasteurisation** (the gentle heat-treatment of milk that keeps it safe to drink), hospital sterilisation practices, and the modern understanding that spores of mould floating in ordinary air are what settle onto your roti or damp wall and begin reproducing — not spontaneous decay.

Activity — Redeveloped: Growing Mould on Purpose

Original book version: Moisten a slice of bread or roti, keep it in a warm, dark, moist chamber for a few days, and examine the resulting mould under a microscope.

Everyday Version:

- Lightly moisten a small piece of leftover roti or bread with a few drops of water.
- Place it on a bed of moist cotton and tissue paper inside a clean steel dabba or plastic box (a moist chamber).
- Keep the closed box in a warm, dark spot — a kitchen cabinet during the monsoon works especially well, since spores in humid air germinate fastest between 25–35 °C.
- Observe daily without touching the roti directly. After about three days, examine the surface with a magnifying glass for fuzzy growth.
- With a teacher's guidance, transfer a little mould onto a microscope slide with cotton blue stain, and look for thread-like hyphae with round spore sacs at the tip.

Why this matters for your fridge: This is precisely why refrigerators exist. Lower temperatures slow or stop spore germination, which is why refrigerated food lasts far longer than food left on a warm kitchen counter — a fact your household almost certainly relies on every single day.

Ready to Go Beyond: Fungi That Clean Up After Us

Mould on bread looks unpleasant, but fungi are quietly essential to society. Because they grow and spread so fast through spore formation, fungi rapidly degrade organic waste and pollutants, and they even help remove heavy metals from industrial waste. Some of our most important antibiotics — including penicillin and amoxicillin — are derived from fungi, and have saved countless lives from bacterial infections.

Scientists have also identified fungal species capable of breaking down certain plastics. Given how much of India's waste stream is plastic, could engineered or naturally occurring plastic-degrading fungi become part of the solution to the plastic pollution crisis? This is an active area of ongoing research.

In every organism discussed so far in this chapter — potato buds, money-plant cuttings, budding yeast and hydra, and spore-forming fungi — the underlying cellular process is **mitosis**: a type of cell division that produces two daughter cells, each carrying the same number of chromosomes as, and genetically identical to, the parent cell. This is why offspring produced asexually are genetically identical clones of their parent. Asexual reproduction is fast and lets organisms increase their population quickly, especially when environmental conditions are favourable.

11.2 Sexual Reproduction

Sexual reproduction involves two parents in the formation of a new individual, and both parents contribute genetic material to the offspring. But this raises an immediate problem: if every generation received a full set of chromosomes from

both parents, the chromosome number would double with each generation. Nature solves this with a special type of cell division called **meiosis**.

11.2.1 Meiosis and the Origin of Variation

Every species has a fixed number of chromosomes in its cells — thread-like structures in the nucleus that carry genetic information. Humans have 23 pairs of chromosomes (46 in total), one chromosome of each pair inherited from each parent.

Meiosis forms gametes (reproductive cells) by reducing the chromosome number of a parent cell from diploid (the full number) to haploid (half). In animals, male gametes are called sperm and female gametes are called eggs. In plants, the pollen grain contains male gametes and delivers them to an ovule, which contains the female gamete (egg). During meiosis, each chromosome pair separates so that every gamete receives only one chromosome from each pair — meaning every human gamete carries 23 chromosomes, each loaded with genetic information for many different characteristics.

> **Activity — Redeveloped: Why Don't You Look Exactly Like Your Sibling?**
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> **Original book version:** Use three pairs of coloured beads (representing hair colour, hair texture and eye colour on three different chromosomes) to model how gametes randomly combine characters, and calculate how many combinations are possible.
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> **Everyday Version:**
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> Take three small dishes, each holding two differently coloured beads or buttons — say, dish 1 has one light-green and one dark-green bead (representing two versions of a trait on chromosome 1), dish 2 has one light-blue and one dark-blue bead (chromosome 2), and dish 3 has one light-red and one dark-red bead (chromosome 3). Without looking, pick one bead from each dish and record the combination — for example, "light-green, dark-blue, light-red."
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> - Repeat this random draw several times. How many times did you get the exact same combination twice?
> - With just 3 pairs, there are $2 \times 2 \times 2 = 8$ possible combinations.
> - Now imagine this same random process happening across all 23 pairs of human chromosomes, each carrying information for many traits at once. The number of possible combinations becomes astronomically large.
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> **The everyday payoff:** This is the real reason you and your sibling — despite sharing the same two parents — can have different heights, skin tones, hair textures, or even different tolerances to lactose or altitude. Every gamete your parents produced carried a different random shuffle of their chromosomes, and you inherited one particular shuffle from each. This variation is not a flaw — accumulated across generations, it is what allows a species to adapt to changing environments, and it is one of the raw materials of evolution.

11.2.2 Sexual Reproduction in Flowering Plants

Flowering plants (angiosperms) are the most diverse group of plants on Earth, and the **flower is their reproductive organ**. A complete flower has four parts,

arranged in whorls from the outside in: the **sepal** (the green, leaf-like covering that protects the flower in the bud stage), the **petal** (the often colourful, fragrant part that attracts pollinators), the **stamen** (the male part), and the **pistil** (the female part).

The stamen consists of a filament and an **anther**, which produces pollen grains containing the male gametes. The pistil has three sub-parts: the **stigma** (at the tip, often flat and sticky), the **style** (a thin tube connecting the stigma to the ovary), and the **ovary** (which contains ovules, and each ovule contains an egg cell — the female gamete).

Everyday Connection: The Hibiscus in Every Indian Garden

The gudhal (hibiscus) flower — grown in almost every Indian garden and courtyard, and offered in worship — is one of the easiest flowers to dissect and is often used precisely for this reason in Indian classrooms. Pull back the green sepals at its base, and you'll find the bright red or pink petals inside. In the centre, a single long tube (the fused filaments of many stamens) carries yellow, powdery anthers partway up its length, while the five-lobed, sticky stigma sits right at its tip — often visibly dusted with its own pollen.

Marigold (genda), grown by the truckload for every festival and wedding in India, shows the same basic plan on a much smaller scale within each tiny floret packed into its familiar dense flower head.

Worked Example — Redeveloped: Dissecting a Flower and Proving Pollination Matters

Original book version: Collect different flowers, observe and tabulate the presence of sepal, petal, stamen and pistil (Activity 11.5); then, using pea plants, bag flower buds with muslin cloth after removing stamens from some, and observe which ones go on to form fruit (Activity 11.6).

Everyday Version:

Step 1 — Structure: Collect a hibiscus, a marigold, and a mustard (sarson) or okra (bhindi) flower from a kitchen garden or nearby field. Working from the outside in, note which floral parts are present in each, using a table like the one below.

Flower part	Hibiscus	Marigold floret	Mustard/Okra
Sepal	Yes	Yes (reduced)	Yes
Petal	Yes	Yes	Yes
Stamen	Yes	Yes	Yes
Pistil	Yes	Yes	Yes

Step 2 — Function, by experiment: On a flowering okra or pea plant, select two unopened flower buds and three freshly opened flowers. Carefully remove the stamens from one bud and from one open flower before they can shed pollen. Loosely cover all five with small muslin-cloth or paper bags, except one open flower, which is left uncovered. After the flowers wither, check which ones go on to form a pod or fruit.

Expected result: Fruit forms in every case except the bud whose stamens

were removed before it could ever release or receive pollen. This shows that the transfer of pollen from anther to stigma — **pollination** — is essential for fruit formation, not merely a decorative side-effect of a flower blooming.

11.2.3 How Pollination Occurs

Pollination is the transfer of pollen grains from the anther to the stigma of a flower. When pollen moves to the stigma of the same flower, or another flower on the same plant, it is called **self-pollination**. When pollen is transferred from the anther of a flower on one plant to the stigma of a flower on a different plant of the same species, it is called **cross-pollination**.

11.2.4 Pollination Strategies and Reproductive Success

Pollination depends on external agents called **pollinators** — wind, water, insects, or birds — and different plants have evolved strikingly different strategies to make sure pollen reaches a compatible stigma.

- **Wind pollination** — seen in wheat, maize and rice. Pollen grains are light, small, and produced in enormous numbers; the stigma is long and feathery to trap drifting pollen.
- **Water pollination** — seen in aquatic plants such as Vallisneria and Hydrilla, where water currents carry pollen from one flower to another.
- **Insect pollination** — seen in sunflower, hibiscus and marigold. Their flowers are brightly coloured, produce nectar, and release fragrance to attract bees and butterflies; the pollen is large, sticky or spiny so it clings to an insect's body, and the stigma is sticky to receive it.
- **Bird pollination** — seen in flowers of the coral tree and hibiscus, visited by birds such as the Indian white-eye and sunbirds.

🌾 Everyday Connection: The Buzzing Mustard Field and Your Morning Roti

Drive through Punjab, Haryana, or Rajasthan between January and February and you'll pass kilometres of golden-yellow mustard (sarson) fields — humming with honeybees. Beekeepers deliberately place hives at the edge of these fields: the bees get nectar and pollen to make sarson ka shahad (mustard honey), and in exchange, they cross-pollinate the mustard flowers far more reliably than wind ever could, boosting the farmer's seed and oil yield.

Meanwhile, the wheat and rice that make up the roti and chawal on an Indian dinner plate rely on wind pollination — no bee ever visits a wheat flower. This is why the feathery, light pollen and long stigmas of cereal crops look so different from the bright, sticky flowers of sunflower or hibiscus: each is precisely built for its own pollination strategy, and both strategies quietly underpin India's food security.

🔬 Worked Example — Redeveloped: Which Pollination Strategy Actually Works Better?

Original book version: Compare pollen production and seed formation data for wind-pollinated grasses versus insect-pollinated plants, and explain why producing huge numbers of pollen grains can still be an effective strategy (Activity 11.7).

Pollination strategy	Pollen grains released per flower	Average seeds formed
Wind-pollinated grasses (maize, wheat)	5,00,000 – 10,00,000	50 – 200
Insect-pollinated plants (sunflower)	20,000 – 40,000	800 – 1,000

Everyday-style Fermi calculation (just like the estimation skills from Chapter 1):

For wind pollination: roughly 5,00,000 ÷ 50 = 10,000 pollen grains are released for every single seed eventually formed, in the least efficient case, and about 5,00,000 pollen grains per seed even at the better end of the range.

For insect pollination: roughly 20,000 ÷ 800 = 25 pollen grains per seed, and at most about 40 pollen grains per seed.

Conclusion: Insect pollination is roughly 100–400 times more efficient per pollen grain than wind pollination. Wind pollination compensates for its randomness by sheer volume — releasing pollen wastefully but in gigantic numbers, so that enough grains land on a receptive stigma purely by chance. Insect pollination is a far more targeted delivery system, so plants that use it can afford to produce dramatically fewer pollen grains for the same, or better, reproductive success.

Ready to Go Beyond: Vanishing Bees, Vanishing Apples

In the lower Himalayan region of Himachal Pradesh, apples are a major cash crop for thousands of farming families. In recent years, apple yields have been declining — a trend researchers link to both climate change and a shrinking population of natural pollinators. Some orchards have responded by combining apple cultivation with managed beekeeping: introducing honeybee colonies directly into the orchard during the flowering season. Farmers following this approach often report improved fruit-setting and reduced premature fruit drop — while also harvesting honey as a bonus crop.

This is a striking real-world reminder that a flower's biology (needing insect-mediated cross-pollination) and an entire regional economy (apple farming livelihoods) can be linked by something as small as a single bee's flight path between blossoms.

11.2.5 Fertilisation and Seed Formation

Once pollen reaches a compatible stigma, it produces a **pollen tube** that grows down through the style into the ovary. The male gamete travels through this tube and reaches the ovule, where it fuses with the egg cell. This fusion of gametes is called **fertilisation**, and it marks the beginning of a new life. The fertilised egg is called a **zygote**, which develops into an embryo. Meanwhile, the ovary surrounding the ovules enlarges and develops into a **fruit**, while the ovules

themselves develop into **seeds** inside it. Seeds are then dispersed by wind, water or animals, and when conditions of water, air and temperature are favourable, a seed germinates and grows into a new plant.

Activity — Redeveloped: The Kitchen Ovary

Original book version: Cut fruits such as tomato, brinjal, papaya and muskmelon longitudinally and transversely, observe seed attachment, and link this to the internal structure of the ovary.

Everyday Version:

Next time you're helping in the kitchen, ask to cut open a tomato, a bhindi (okra), a brinjal (baingan), and a papaya — once lengthwise (longitudinal section) and once across (transverse section). For each:

- Locate the seeds and note how they are attached inside — usually along a central column or ridge, which is exactly where the ovule-bearing tissue of the ovary was.
- Count roughly how many seed-bearing chambers (locules) each fruit has when cut transversely — tomato typically shows 2–4 clear chambers.
- Match what you see to Fig. 11.10's flower diagram: the fruit you're holding is simply the mature, enlarged ovary; each seed inside it is a mature, fertilised ovule.

Why it clicks: Every vegetable your family cooks with seeds inside — tomato, brinjal, capsicum, okra, cucumber — is, biologically speaking, a fruit: the direct, edible result of successful pollination and fertilisation weeks or months earlier in that plant's life.

Meet a Scientist: P. Maheshwari — Father of Indian Embryology

Panchanan Maheshwari (1904–1966) was a leading Indian botanist in the field of embryology — the study of how plant reproductive organs develop. He successfully fused an egg and a male gamete of a flowering plant in a test tube, developing an early technique of **in-vitro fertilisation in flowering plants** to create new hybrid plants, and was among the first scientists in the world to grow plant embryos on artificial nutrient media outside the parent plant. His 1950 book, *An Introduction to the Embryology of Angiosperms*, became a classic reference still used by botanists worldwide.

His work sits at the exact intersection this chapter has been building towards: understanding fertilisation and seed formation well enough to deliberately recreate and control it in a laboratory — a foundation for modern plant breeding.

Sexual reproduction in plants has direct applications in agriculture through **plant breeding**. In **selective breeding**, farmers choose plants with desirable characteristics for reproduction. **Artificial hybridisation** involves removing the stamens from a flower, bagging it to prevent self-pollination, and then manually transferring pollen from a plant with a desired trait. **Genetic engineering** goes further, inserting genetic material for a desired trait directly into the DNA of a chosen plant variety. Together, these methods have produced high-yielding and disease-resistant crop varieties, and have revolutionised crop production across

India — from the Green Revolution wheat varieties of Punjab to today's disease-resistant vegetable hybrids.

11.3 Sexual Reproduction in Animals

Animals reproduce through asexual and/or sexual methods — we have already seen budding in hydra earlier in this chapter. In many aquatic animals with sexual reproduction, such as frogs and most fish, fertilisation happens **outside the body**: the female releases eggs into the water and the male releases sperm over them. This is called **external fertilisation**. Although a large number of eggs are laid, many are destroyed by water currents or eaten by predators. In reptiles, birds and mammals, fertilisation takes place **inside the female's body** — **internal fertilisation** — where the fertilised egg or embryo is generally better protected, giving the young ones a higher chance of survival.

> **Everyday Connection: The Monsoon Chorus in Every Indian Pond**
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> The loud, overlapping croaking that fills the air near ponds, puddles and paddy fields on the first rainy nights of the monsoon is male frogs calling to attract females. Frogs time their breeding precisely to the rains because their fertilisation is external and depends entirely on standing water: the female releases hundreds to thousands of eggs directly into the water, and the male fertilises them externally as they are laid. You can often see the resulting jelly-like clusters of frog eggs, and later swarms of tadpoles, in the very same puddles days later.
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> This is a direct, audible, seasonal demonstration of external fertilisation happening in real time, right outside an Indian home during the monsoon.

11.4 Variations in Reproduction in Animals

All animals face the same basic challenge: ensuring male and female gametes meet, and that enough young ones survive long enough to grow and reproduce themselves. Different animal groups solve this challenge very differently.

Animal	Habitat	Mode of fertilisation	Eggs produced	Survival of young
Fish	Water	External	100s – 1000s at a time	Low
Frog	Water/land	External	5,000 – 50,000 at a time	Low
Lizard	Land	Internal	2 – 20 at a time	Moderate

Animal	Habitat	Mode of fertilisation	Eggs produced	Survival of young
Bird	Water/land	Internal	1 – 15 at a time	Moderate to High

Fish, amphibians and insects produce hundreds to thousands of eggs at a time, each with just enough yolk (a nutritive substance) to hatch a **larva** — an intermediate, feeding stage of development. The larva then feeds on organic matter in its surroundings, grows, and eventually transforms into the adult body — as seen in the egg → larva → pupa → adult life cycle of a butterfly. In contrast, reptile and bird eggs each contain enough yolk to nourish the embryo all the way through to hatching as a young one. In mammals, the zygote develops entirely inside the female's body, nourished directly by her, without relying on stored yolk at all.

> **Everyday Connection: The Silk on a Wedding Saree**
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> The complete metamorphosis of an insect — egg, larva, pupa, adult — is the biological basis of one of India's most famous textile industries. The silk moth *Bombyx mori* lays hundreds of eggs, which hatch into silkworm larvae. These larvae feed voraciously on mulberry leaves before spinning a protective pupal case — the cocoon — made of a single continuous silk thread that can stretch to over 900 metres. Sericulture farms across Karnataka, West Bengal and Andhra Pradesh manage this exact life cycle at scale: eggs are hatched, larvae are fed mulberry leaves, and cocoons are harvested (before or after the adult moth emerges, depending on the type of silk) and unwound into the raw silk thread that eventually becomes a wedding saree.
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> Every silk garment is, quite literally, a product of an insect's larval and pupal reproductive biology, harvested at precisely the right stage of its life cycle.

11.5 Reproduction in Human Beings

As a child grows into an adult, reproductive organs mature and begin producing gametes — sperm in males and eggs in females. This section looks at how those gametes form and meet, and how a new human life develops.

11.5.1 Reproductive Maturity

The physical and emotional changes that occur as reproductive organs mature and begin producing gametes are collectively known as **puberty**. This process brings visible physical changes as well as the internal capacity for reproduction, and unfolds gradually rather than overnight.

11.5.2 The Male Reproductive System

The male reproductive system produces male germ cells called **sperm** and transfers them to the female body. Sperm are produced in a pair of oval-shaped organs called the **testes**, held in a pouch of skin called the **scrotum**. The scrotum

keeps the testes slightly cooler than normal body temperature, which is necessary for sperm formation. The testes also produce a hormone that controls sperm production and causes the physical changes seen in boys during puberty.

From the testes, sperm travel through a long tube called the **vas deferens**, which opens into the **urethra** — a shared passage for both urine and sperm. Glands such as the **seminal vesicles** and the **prostate gland** add fluids that nourish the sperm and help them stay active and mobile. Each sperm has a head containing genetic material and a long tail that helps it swim towards the egg.

11.5.3 The Female Reproductive System

The female reproductive system consists of a pair of **ovaries**, a pair of **oviducts** (fallopian tubes), a **uterus**, and a **vagina**. The ovaries produce the female germ cells (eggs) and release hormones that bring about the changes of puberty. The oviducts connect each ovary to the uterus — a bag-like structure where a foetus develops. The uterus opens into the vagina through a narrow passage called the **cervix**.

11.5.4 How Are Reproductive Cells Made? (Gametogenesis)

The formation of gametes is called **gametogenesis**, and it takes place in the testes and ovaries through meiosis, which halves the chromosome number. Human body cells carry 46 chromosomes, while sperm and eggs carry only 23 — so that when they combine at fertilisation, the resulting zygote has the full 46 chromosomes again, matching the parents. In males, gametogenesis produces enormous numbers of tiny, motile sperm; in females, it produces a single large egg at a time. Sperm and eggs differ greatly in size, number and structure.

Feature	Sperm	Egg
Size	Very small	Large
Number produced	Millions	Few
Stored nutrients	Absent	Present
Motility	Actively motile	Non-motile

11.5.5 What Happens When a Sperm Meets an Egg?

At birth, a girl's ovaries already contain millions of immature eggs. From puberty onwards, usually one mature egg is released every month from one of the ovaries — a process called **ovulation**. Before ovulation, the inner lining of the uterus begins to thicken in preparation. As the egg is released, it travels from the ovary into the oviduct. If sperm are present in the reproductive tract and one succeeds in fusing with the egg, a **zygote** forms. The uterine lining then becomes thicker and richer in blood vessels, and the zygote undergoes repeated mitotic divisions while travelling towards the uterus, where it implants into the thickened lining to receive nourishment. This implantation marks the beginning of **pregnancy**.

11.5.6 What Happens When an Egg Is Not Fertilised? (Menstruation)

If an egg is not fertilised, it remains viable for about a day and then degenerates. The thickened, blood-vessel-rich uterine lining that had prepared to receive a zygote is no longer needed, so it sheds, leaving the body through the vagina along

with some blood. This process is called **menstruation** or a period, and it typically lasts 3 to 7 days. The entire cycle — ovulation, preparation of the uterine lining, and menstruation — repeats roughly every 21–35 days (often close to 28 days), usually beginning at puberty between the ages of 10–14 and continuing until menopause, around age 50.

Days 1–5	Days 6–14	Day 14	Days 15–28
Menstruation (shedding of uterine lining)	Uterine lining rebuilds; egg matures in ovary	Ovulation (ovary releases a mature egg)	Uterine lining thickens further; if no fertilisation occurs, it breaks down around day 28 and the cycle repeats

Everyday Connection: Periods Are Getting Less Silent in Indian Schools

Menstrual hygiene management has become a visible priority in Indian schools in recent years. Many government and private schools now install low-cost sanitary pad vending machines and incinerators in girls' washrooms, and state governments run schemes distributing free or subsidised sanitary napkins to students. This is a direct, practical response to what this chapter describes biologically: menstruation is a normal, healthy, recurring physiological event, not something to hide or feel ashamed of.

Good hygiene practice during a period includes using clean menstrual products (biodegradable pads, tampons, or menstrual cups), washing the genital area with water rather than soap, washing hands before and after changing a pad, disposing of used products responsibly (wrapped, in a bin — never flushed), and changing products every 4–6 hours, or more frequently during heavy flow.

Thread of Curiosity: What Determines a Baby's Biological Sex?

Every person has two sex chromosomes: females carry XX, and males carry XY. The mother always contributes an X chromosome to her child. The father, however, contributes either an X (resulting in a girl, XX) or a Y (resulting in a boy, XY). Based on this alone, whose chromosome actually determines the biological sex of a baby — the mother's or the father's?

This single fact of chromosome biology directly contradicts a persistent and harmful social belief in many communities that a mother is somehow "responsible" for the sex of her child. Biologically, it is the father's contribution — X or Y — that decides it.

11.5.7 Pregnancy and Childbirth

Human pregnancy lasts about nine months, divided into three stages called **trimesters**. In the **first trimester**, the fertilised egg develops into an embryo over the first two months, and major organs begin forming; from about the ninth week onward, the developing individual is called a **foetus**. In the **second trimester**, the foetus grows bigger and stronger, and the mother can usually feel

its movements. In the **third trimester**, the baby grows rapidly and prepares for life outside the womb. During childbirth, strong contractions of the uterine muscles push the foetus out through the birth canal; where a normal vaginal birth is not possible or safe, doctors may use medical or surgical procedures to deliver the baby safely.

After birth, breastfeeding is essential, since a mother's milk provides complete nutrition and protects the infant against many diseases. Newborns need to be kept warm, vaccinated on schedule, and handled gently. The mother's well-being matters just as much — she needs nutritious food, adequate rest, and should avoid smoking, alcohol, and any medicines not advised by a doctor.

> **Everyday Connection: The ASHA Worker in the Village**
>
> Across rural India, more than 10 lakh **Accredited Social Health Activist (ASHA)** workers — trained women embedded in their own communities — are the human face of maternal healthcare under the National Health Mission. An ASHA worker visits pregnant women for check-ups, advises on nutrition and safe delivery, helps arrange transport to a hospital when labour begins, and later counsels new mothers on newborn care, immunisation schedules, and contraceptive options.
>
> Some mothers experience **post-partum depression** — a recognised, treatable form of anxiety and exhaustion following childbirth. Mothers experiencing this are encouraged to talk to a healthcare worker, such as a doctor, nurse, or ASHA worker, rather than suffering in silence, so they can get proper help and support.

11.5.8 Mother's Health During Pregnancy

A woman's health during pregnancy plays a vital role in her baby's growth and safety. She should eat a balanced diet rich in proteins, vitamins and minerals, attend regular medical check-ups, and follow her doctor's advice on rest and light exercise. Her emotional well-being matters too, and support from family members helps her remain healthy and stress-free.

11.5.9 Sexual Maturity vs Emotional Maturity

As adolescents grow, their bodies gradually become capable of reproduction — a process called sexual maturation, seen in the production of sperm in boys and the start of menstrual cycles in girls. This does **not** mean a teenager is ready for adult responsibilities. Sexual maturity happens gradually alongside overall body growth, but **emotional maturity** — the ability to handle feelings, communicate clearly, and make thoughtful decisions — takes considerably longer to develop.

11.5.10 Preventing Unwanted Pregnancies and Infections

Being ready for sexual activity is not only about physical changes but also about the capacity to make thoughtful, responsible decisions — choices that help prevent unplanned pregnancy, sexually transmitted infections, and support healthy relationships. Because sexual activity involves close physical contact, certain infections — called **Sexually Transmitted Infections (STIs)** — can pass from an infected person to an uninfected one. These include gonorrhoea, herpes, syphilis, genital warts, and HIV (which can eventually lead to AIDS); some of these

are not yet curable. Using condoms helps prevent transmission of STIs and also helps prevent pregnancy.

Several **contraceptive** (pregnancy-preventing) methods exist. Barrier methods, such as condoms or vaginal covers, physically stop sperm from reaching the egg. Hormonal methods, such as oral contraceptive pills, alter the release of eggs, though they can carry side effects. **Intra-Uterine Devices (IUDs)**, such as the copper-T, are placed inside the uterus to prevent pregnancy, though they may occasionally cause irritation. Surgical methods block the vas deferens in males or the fallopian tubes in females, permanently preventing sperm and egg from meeting. In some cases, an unwanted pregnancy may be ended through a surgical procedure called **abortion**, generally only within the first trimester, when the embryo is still very small.

A serious and unlawful misuse of prenatal technology in India is **sex-selective abortion**, driven by a preference for a particular gender. This practice has led to a marked imbalance in the societal sex ratio in some regions, and for this reason, prenatal sex determination is strictly prohibited by law in India — under the Pre-Conception and Prenatal Diagnostic Techniques (PCPNDT) Act — to protect the health of a balanced, forward-looking society.

Everyday Connection: An Indian-Made Contraceptive Pill, Free for Every Citizen

Scientists at the **Central Drug Research Institute (CDRI), Lucknow**, developed the world's first non-steroidal, non-hormonal oral contraceptive pill — commonly known as **Saheli**. Taken just once a week, it avoids many of the side effects (weight gain, nausea, headaches) associated with hormonal pills. It is safe, convenient, effective, and provided free of cost through India's National Family Planning Programme — a piece of home-grown Indian scientific research directly shaping reproductive healthcare for millions.

Meet a Scientist: Subhash Mukhopadhyay — India's IVF Pioneer

In-vitro fertilisation (IVF) is a medical technique in which an egg and a sperm are combined outside the body, typically in a laboratory culture dish. The resulting fertilised egg is then implanted in the uterus to begin a possible pregnancy — commonly (if inaccurately) called a "test-tube baby," since the process actually happens in a culture dish, not a test tube.

Subhash Mukhopadhyay, a physician from Kolkata, pioneered India's first IVF baby in 1978 — Kanupriya Agarwal, nicknamed Durga — using an independently developed method of cryopreserving and transferring embryos, only a few months after Louise Brown became the world's first IVF baby in the United Kingdom that same year. India therefore holds a genuinely significant place in the global history of IVF, achieved through pioneering, largely self-directed research.

Ready to Go Beyond: One Chromosome, One Persistent Myth

You now have all the biological knowledge needed to correct a harmful and widespread misconception: that a mother "decides" or is somehow at fault for

the sex of her baby. The mother always contributes an X chromosome; it is the father's X or Y chromosome that determines whether a baby is XX (female) or XY (male). This is exactly why India's law against prenatal sex determination and sex-selective abortion — the PCPNDT Act — matters so much: it protects against a practice built on a scientifically false premise, one that has already visibly skewed the sex ratio in several regions of the country.

Next time you hear this myth repeated in your own family or neighbourhood, you now have the precise chromosomal reasoning to correct it.

Chapter Summary

Concept	Core idea	Everyday example
Asexual reproduction	One parent produces genetically identical offspring (clones)	Potato eyes sprouting, money-plant cuttings rooting in water
Vegetative propagation methods	Cutting, grafting, layering and tissue culture multiply a single parent plant	Grafted Alphonso mango trees, tissue-culture banana plantlets
Budding	A new individual grows as an outgrowth of the parent and detaches	Yeast budding in a fermenting dough, hydra budding in a pond
Spore formation	Lightweight spores disperse through air and germinate where conditions suit	Mould appearing on monsoon-damp roti, bread, or walls
Mitosis	Cell division producing genetically identical daughter cells	The basis of every asexual method above
Meiosis and variation	Halves chromosome number to form haploid gametes; random combinations create variation	Siblings inheriting different traits from the same two parents
Flower structure	Sepal, petal, stamen (male) and pistil (female) each serve a distinct function	Dissecting a hibiscus or marigold flower
Pollination	Transfer of pollen from anther to stigma — self or cross, via wind, water, insects or birds	Bees pollinating mustard fields; wind pollinating wheat and rice
Fertilisation and seed formation	Fusion of gametes forms a zygote; ovule becomes seed, ovary becomes fruit	Seeds found inside a tomato, brinjal, or okra cut in the kitchen
External vs internal	Fertilisation outside vs inside the body	Frogs spawning in

Concept	Core idea	Everyday example
fertilisation	affects egg number and survival	monsoon ponds vs birds incubating eggs in nests
Human reproductive systems	Specialised organs produce and transport gametes in males and females	Testes and ovaries maturing during puberty
Menstrual cycle	A roughly 28-day cycle of ovulation and uterine lining renewal	Monthly periods and school menstrual hygiene programmes
Pregnancy and childbirth	Zygote develops into embryo, then foetus, over three trimesters	Nine-month pregnancy supported by ASHA worker check-ups
Contraception and STI prevention	Barrier, hormonal, IUD and surgical methods prevent pregnancy and infection	Condoms, the India-developed Saheli pill, Copper-T IUDs

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□ Revise, Reflect, Refine — Exercises

Basic Recall

1. Differentiate between asexual and sexual reproduction, giving one plant example of each.

2. What is the function of each part of a flower — sepal, petal, stamen and pistil?

3. Name the male and female reproductive organs in humans, and state one product or function of each.

Apply & Think

4. A farmer removes the stamens from a brinjal flower bud and bags it before it opens; no fruit forms. A neighbouring, untouched flower on the same plant forms fruit normally. Explain what this experiment demonstrates about pollination.

5. Using what you know about mitosis and meiosis, explain why a plant grown from a stem cutting is genetically identical to its parent, while a plant grown from a seed is not.

6. Your cousin insists, "It's the mother who decides whether her baby is a boy or a girl." Using your understanding of sex chromosomes, evaluate whether this claim is scientifically correct, and explain your reasoning.

Creative Design Challenges □

7. **The Propagation Passport:** Choose five plants from your home or neighbourhood. For each, identify which method — cutting, grafting, layering, tissue culture, or growing from seed — would best multiply it, and explain your reasoning.

8. **The Pollen's Journey:** Create a comic strip or flowchart tracing the journey of a single pollen grain from an anther on a mustard flower all the way to a ripe mustard seed inside its pod.

9. **The Period-Positive Poster:** Design an awareness poster, using at least three concrete facts from this chapter, aimed at reducing stigma around menstruation for display in your school corridor.

10. **Save the Himalayan Apple:** Imagine you are a horticulturist advising a Himachal Pradesh apple farmer whose local bee population has collapsed. Propose a science-based action plan, drawing on what you've learned about pollination strategies.

□ Journey Beyond — Going Deeper

Challenge A — Saving India's Seed Heritage: Research the Government of India's Beej Gram Yojana (Seed Village Programme). Why does saving indigenous seed varieties matter for genetic diversity and food security? If possible, interview a local farmer about which seed varieties — indigenous or hybrid — they prefer to sow, and why.

Challenge B — India's Reproductive Health Innovations: Prepare a short report on India's contributions to reproductive healthcare — the country's early IVF history, and the development of the Saheli contraceptive pill at CDRI Lucknow. What made each of these a genuine scientific breakthrough, and what barriers (technical or social) did they have to overcome?

Challenge C — The Quest Continues: Does a unicellular organism like an amoeba or a yeast cell ever truly "grow old"? When it divides, it produces two nearly identical copies of itself, over and over. Investigate the idea of biological immortality in single-celled organisms, and contrast it with ageing in multicellular organisms like humans. Does the concept of "death" even apply the same way to a dividing amoeba?

Happy Exploring! From a sprouting potato eye to a buzzing mustard field to the biology of your own growing body — life finds relentlessly inventive ways to continue itself. □□